6. The Economy, Welfare and Endogenous Productivity Growth

A feature of each of the production submodels in the JWS model is that an industry's productivity growth can be biased toward some inputs and away from others. By allowing biased productivity growth, the submodel separate price-induced changes in factor use from those resulting from technical change. The rate of productivity growth in each industry consists of a temporal component that varies with time but not with policy conditions and an endogenous component that varies with policy-induced changes in relative input prices. For the economy as a whole, productivity growth depends on the combination of forces operating within each producing sector and the mix of industries underlying the economy's expansion path.

This analysis examines the importance of the technical biases or endogenous productivity growth in simulating the removal of the CAA compliance costs. It was accomplished by "zeroing-out" the econometrically estimated bias coefficients in each industry. With the biases set to zero, productivity growth within each sector is limited to its exogenous component which, at each point in time, is invariant across policy alternatives. Thus, any overall productivity differences between the base and counterfactual simulations depend entirely on changes in the industrial mix, i.e., there are no technical biases or price-induced productivity changes.

Table 6.1 shows reductions through 1990 in the aggregate price of domestic output relative to the price of labor received by households. With the CAA and endogenous productivity growth, the relative price of output declines by 10.2 percent. Productivity contributes 5.6 percentage points to this decline while capital and the energy-material aggregates each contribute 4.0 percentage points. These gains are eroded partially by the structuring toward more labor intensive industries. Elimination of the technical biases slows the overall rate of relative price decline. Capital and the energy-materials aggregate contribute substantially less while the offsetting influence of labor increases slightly. This implies that the economy-wide impacts of endogenous productivity growth of the sector level are, in this instance, labor-saving and capital- and energy-materials-using. However, the overall productivity benefit increases with the elimination of the technical biases. This means that their collective presence over the historical period involves a small but measurable cost reflected in biases toward the purchases of those factors which were becoming relatively more expensive.

Table 6.1
The Role Of Endogenous Productivity Growth

Percentage Changes in the Relative Price of Total Domestic Industry Output, 1990

		With Technical Biases	Without Technical Biases	Difference
With CAA	Overall	-10.2	-6.6	-3.6 .
	Contributions of:			
	Labor	+3.4	+3.7	-0.3
	Capital	-4.0	-2.2	-1.8
	Energy, Materials	-4.0	-2.1	-1.9
	Productivity	-5.6	-6.0	+0.4
Without CAA	Overall	-10.6	-7.0	-3.6
	Contributions of:			
	Labor	+3.4	+3.7	-0.3
	Capital	-4.3	-2.4	-1.9
	Energy, Materials	-4.1	-2.3	-1.8
	Productivity	-5.6	-6.0	+0.4
Difference	Overall	-0.4.	-0.4	+0.0
	Contributions of:			
	Labor	0	0	0
	Capital	-0.3	-0.2	-0.1
	Energy, Materials	-0.1	-0.2	+0.1
	Productivity	0	0	0

Reductions measured in percent relative to the *numeraire* price of labor services received by households. Errors in differences or balances are due to rounding.

The qualitative patterns of adjustment are identical for the economy without the CAA compliance costs. With endogenous productivity growth, capital, energy-materials and productivity contribute to the relative price decline while labor changes partially offset these. Technical change without the CAA costs is capital and energy-materials using and slightly labor-saving. Also, the biases exert a small dampening influence on the overall rate of price decline

Within each of the policy settings, elimination of the technical biases substantially slows the rate of substitution of capital for labor while slightly accelerating the contribution of productivity. Again, the latter occurs because the technical biases tend, over the historical period, to push the economy toward those inputs that are becoming relatively more expensive. When the biases are eliminated, this no longer occurs and productivity contributes slightly more.

Of more interest, however, is the role of endogenous productivity growth across the policy settings. As shown Table 6.1, elimination of the CAA compliance costs is both labor and productivity neutral in terms of price effects. The relative price reductions secured by the elimination of the CAA costs are identical in absence of the technical biases. The differences that do occur are related to capital accumulation and the compounding influences on costs and prices secured through endogenous productivity growth. The transition to an economy without the CAA is slightly more capital-using with endogenous productivity growth than it is without endogenous productivity growth.

Productivity-related differences between the base and counterfactual simulations depend little on endogenous technical change within sectors and rather more heavily on changes in the mix of industries, each with a different productivity level. This follows clearly from a comparison of the simulations without technical biases. Here, the productivity levels at each point in time within each industry are identical across cases. Therefore, differences in aggregate productivity and its growth depend only on compositional differences between the economy with the CAA and that without it.

Table 6.2 and Figures 6.1 through 6.4 present information on quantities for these simulations over the period, 1973-1990. Elimination of endogenous productivity growth reduces real income (Figure 6.2) and, by raising future prices comparatively more, promotes current consumption (Figure 6.3). This reduces the savings flow from current income which restricts investment and slows the rate of capital accumulation (Figure 6.4). Stated another way, higher

Table 6.2
The Role Of Endogenous Productivity Growth

The Average Percentage Change in Selected Economic Measures, 1973-1990

		With Technical Biases	Without Technical Biases	Difference
With CAA				
	Capital Stock	0.0	-7.9	+7.9
	Household Income	0.0	-2.9	+2.9
	Consumption	0.0	+2.8	-2.8
	Consumption, Leisure	0.0	+1.1	-1.1
Without CAA				
	Capital Stock	+0.9	-7.2	+8.0
	Household Income	+0.7	-2.3	+3.0
	Consumption	+0.7	+3.3	-2.6
	Consumption, Leisure	+0.2	+1.3	-1.1
Difference				
	Capital Stock	+0.9	+0.8	+0. 1
	Household Income	+0.7	+0.6	+0. 1
	Consumption	+0.7	+0.6	+0.2
	Consumption, Leisure	+0.2	+0.2	+0.0

All variables originally are measured in billions of 1982 dollars. The percentage differences are computed for each year relative to the base simulation. i.e., with the CAA and endogenous productivity growth. The average percentage changes over the period 1973-1990 then are determined Errors in differences or balances are due to rounding.

Figure 6.1

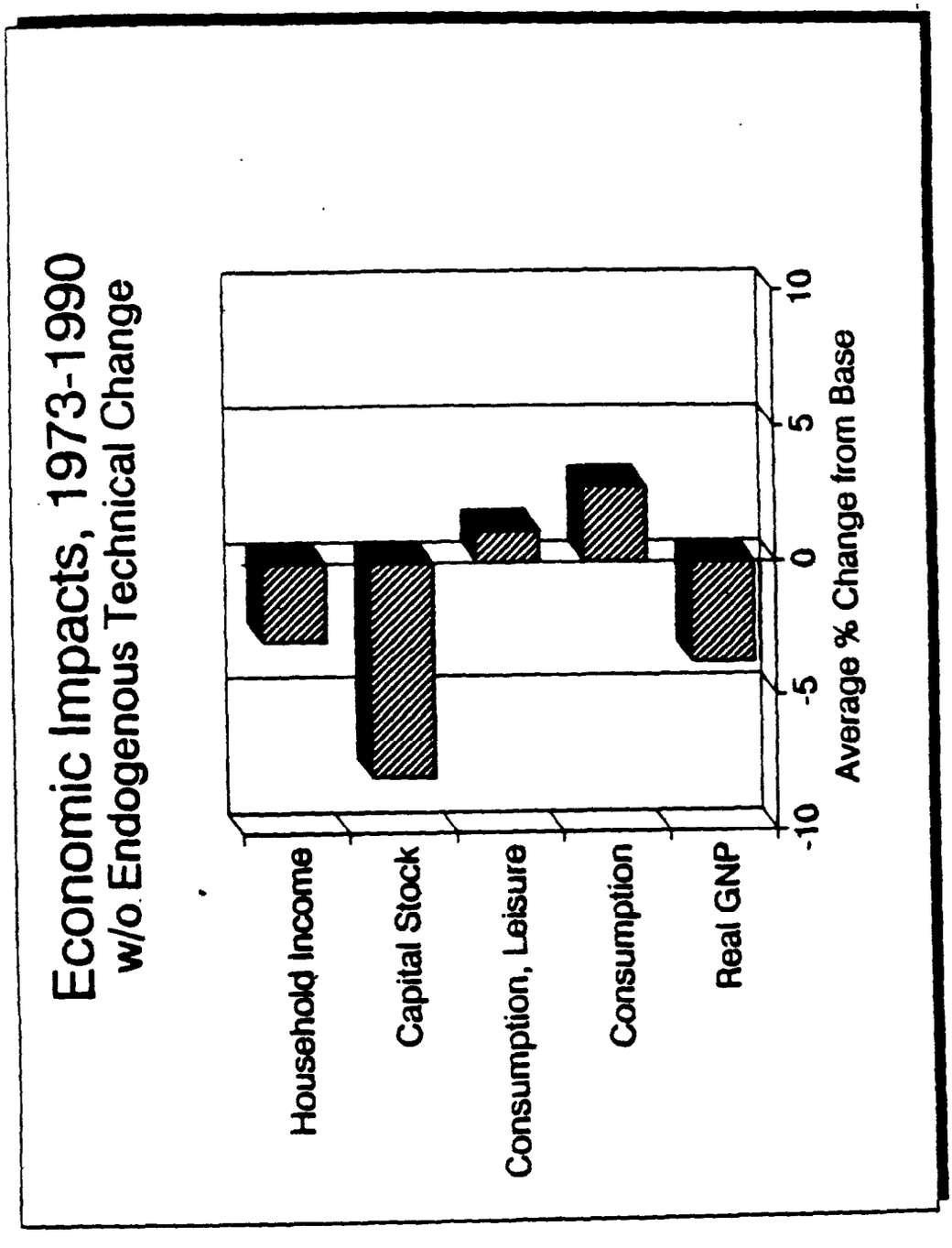

Economic Impacts, 1973-1990
w/o Endogenous Technical Change
Household Income
Capital Stock
Consumption, Leisure
Consumption
Real GNP
-10
-5
0
5
10
Average % Change from Base

Figure 6.2

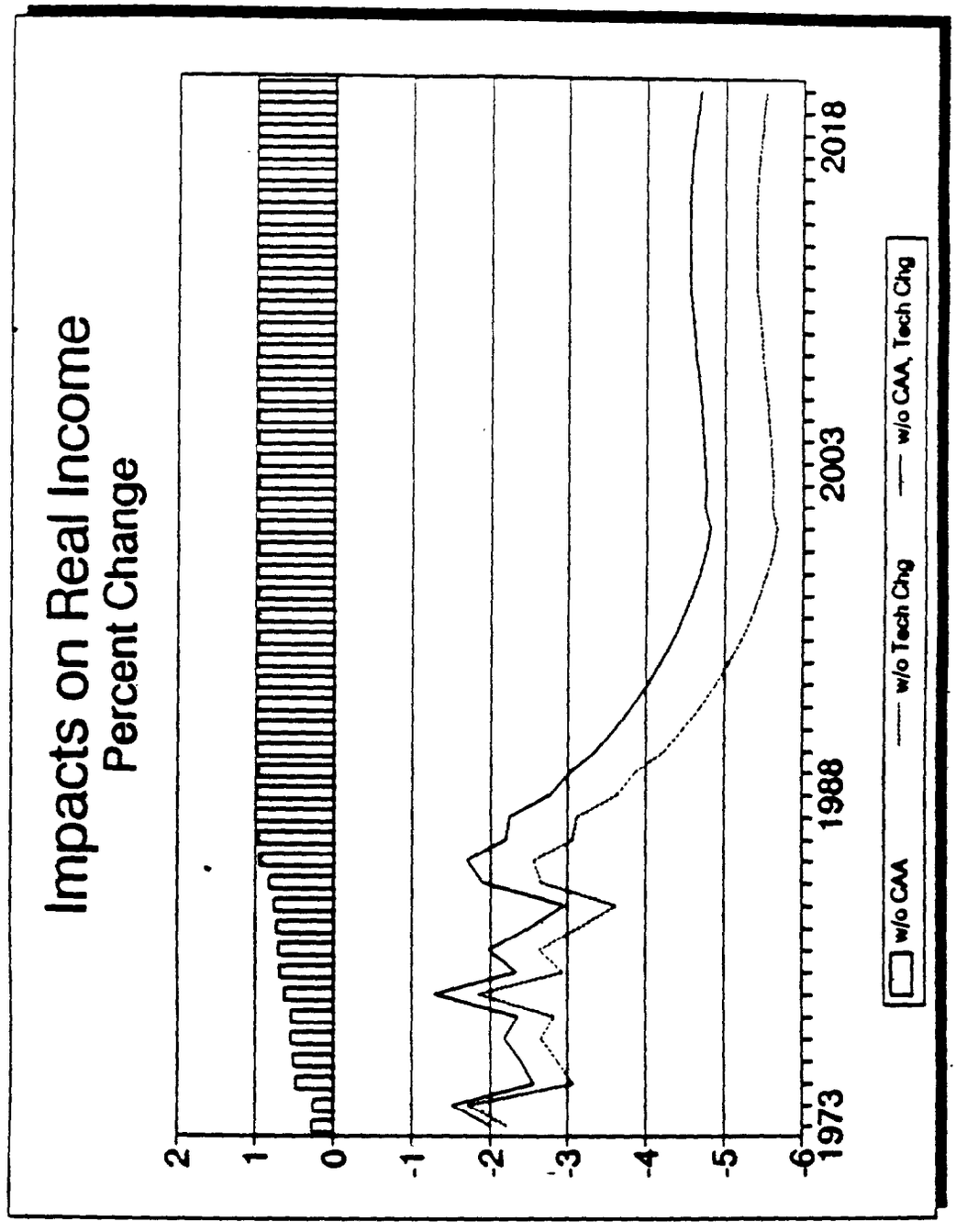

Impacts on Real Income
Percent Change
2
1
0
-1
-2
-3
-4
-5
-6
1973
1988
2003
2018
w/o CAA
w/o Tech Chg
w/o CAA, Tech Chg

Figure 6.3

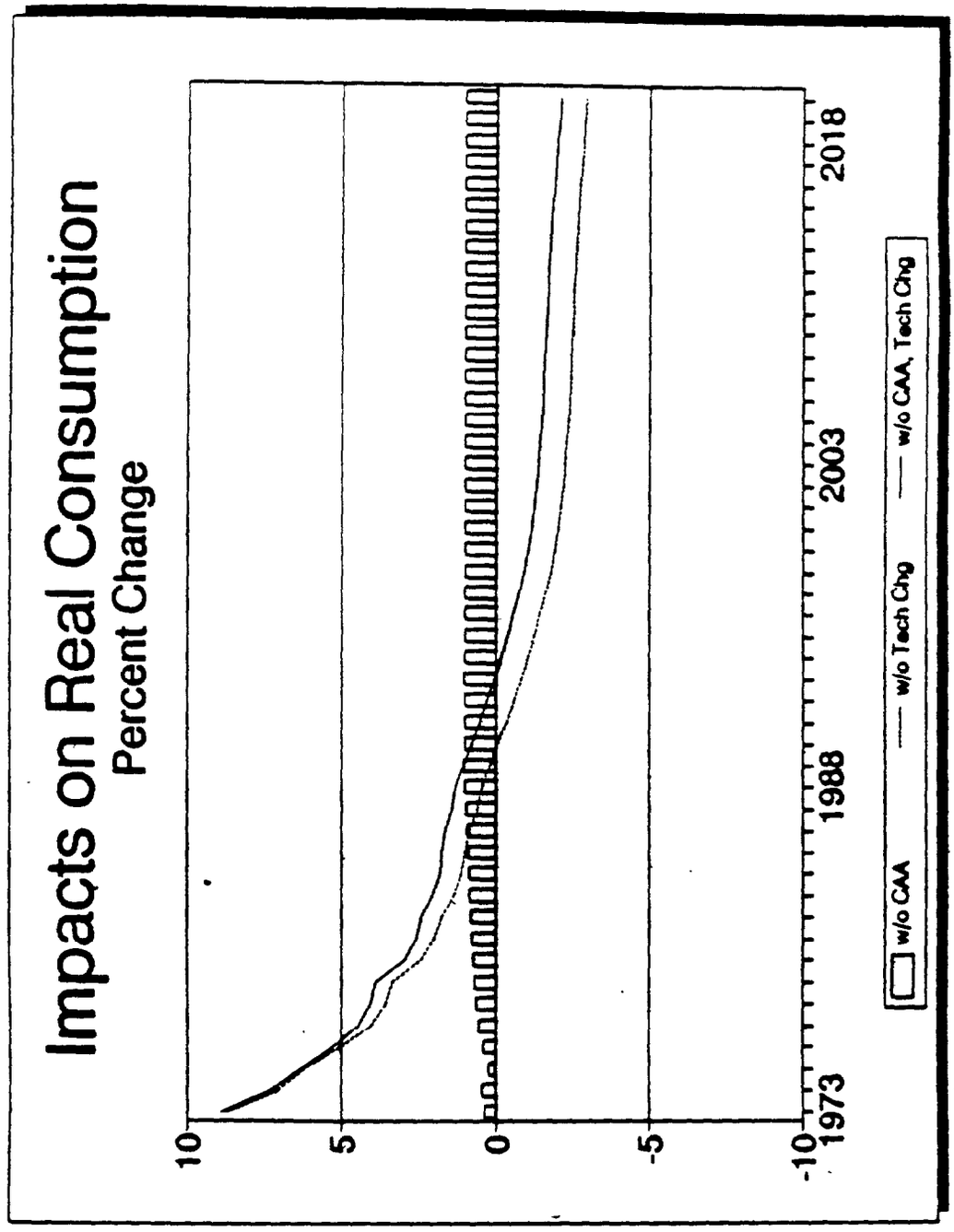
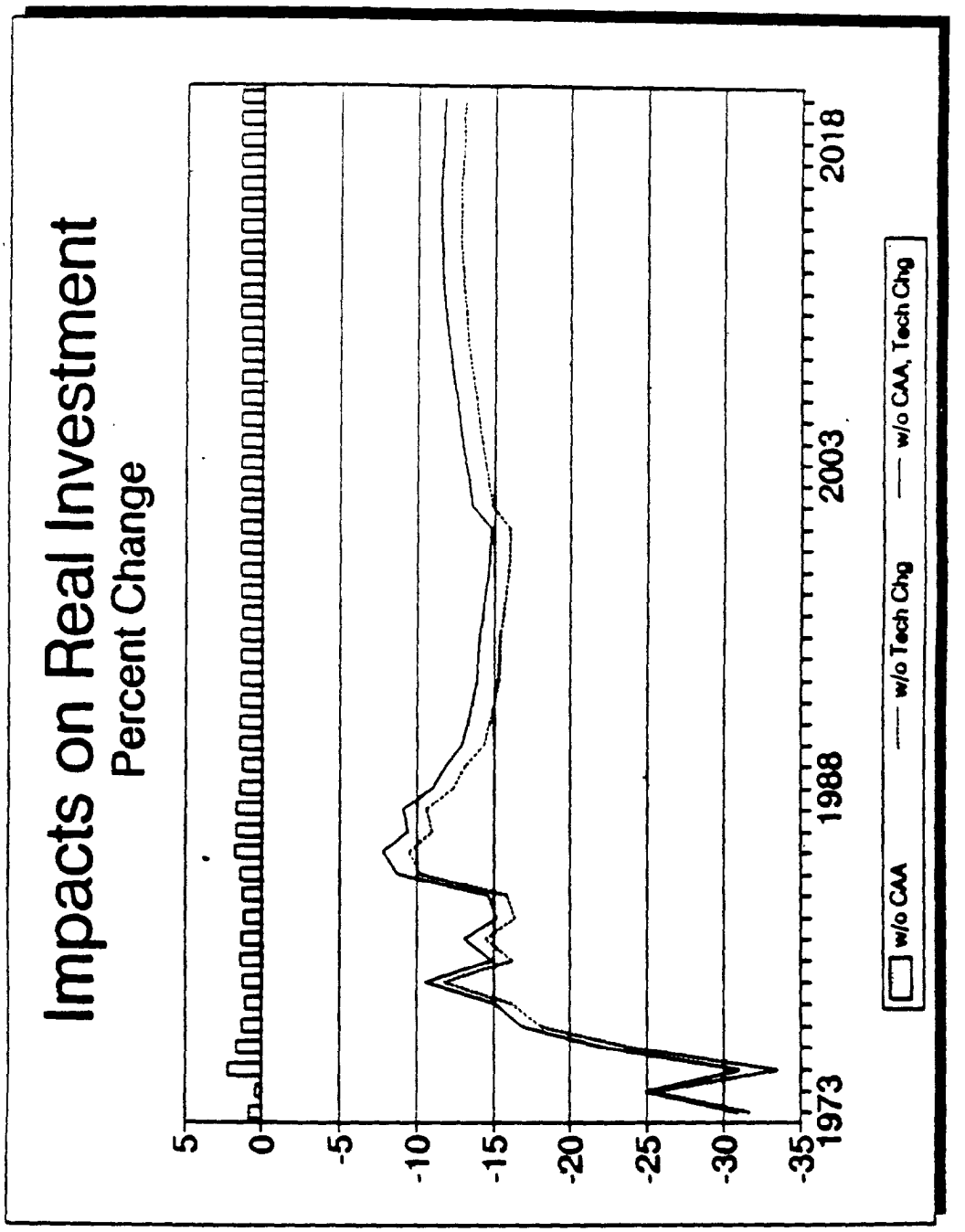

Impacts on Real Consumption
Percent Change
10
5
0
-5
-10
1973
1988
2003
2018
w/o CAA
w/o Tech Chg
w/o CAA, Tech Chg

Figure 6.4


Impacts on Real Investment
Percent Change
5
0
-5
-10
-15
-20
-25
-30
-35
1973
1988
2003
2018
w/o CAA
w/o Tech Chg
w/o CAA, Tech Chg

future prices reduce the real rates of return on savings and investment. For businesses, there is less incentive to invest and, due to the reductions in capital income, a smaller pool of funds (business savings) from which to finance investment. For households, there also is less incentive to save and invest and, so, expenditures from diminished current income rise. These adjustments are qualitatively identical for each of the policy settings.

Setting the technical biases to zero has a more significant impact on the composition of domestic supply and the structure of labor services to industry than was observed for overall macroeconomic performance. Higher future prices and reduced real incomes and spending adversely affect demand in virtually all sectors. As shown in Figure 6.5, domestic supply by commodity is lower in 1990 in all but four sectors - textiles, apparel, lumber and leather. For the most part, these reductions are in line with the declines observed for the components of final demand; by 1990, real consumption has returned to its base case level with real investment restricted by the decline in real private savings and real government purchases constrained by lower tax revenues. However, some sectors experience more dramatic changes in demand. Of these, the energy sectors - coal, oil and gas extraction, petroleum refining, and electric and gas utilities - are noteworthy. In terms of the estimated technical biases, the vast majority of the economy's producing sectors - 32 out of 35 - are energy-using. That is, in absence of changes in relative prices, energy's share of total cost increases over time. Setting the technical biases to zero eliminates these effects so that energy demand and supply grow much more slowly over time and, by 1990, decline significantly relative to the base case. This type of mechanism also explains the rise in textile use. The textiles and apparels industries are highly interdependent (the former more so on the latter) and are materials-saving with respect to their technical biases. Setting these to zero accelerates demand and supply growth, reinforcing relative price and consumption effects. This is particularly true for textiles.

Changes in the structure of labor services by industry, while less straightforward than demand and supply, nevertheless follow from similar mechanisms. These changes are illustrated in Figure 6.6. Seventeen sectors show increases in labor inputs relative to the base case with agriculture, food and communication being the largest. In all but the leather industry, output declines as the technical biases are set to zero. But, in these seventeen industries, the estimated technical biases are labor-saving implying that labor's share of total cost declines over time, *ceteris paribus*. As the biases are set to zero, labor's share rises relative to the base case, the use of labor services increases and labor-output ratios rise,

Figure 6.5

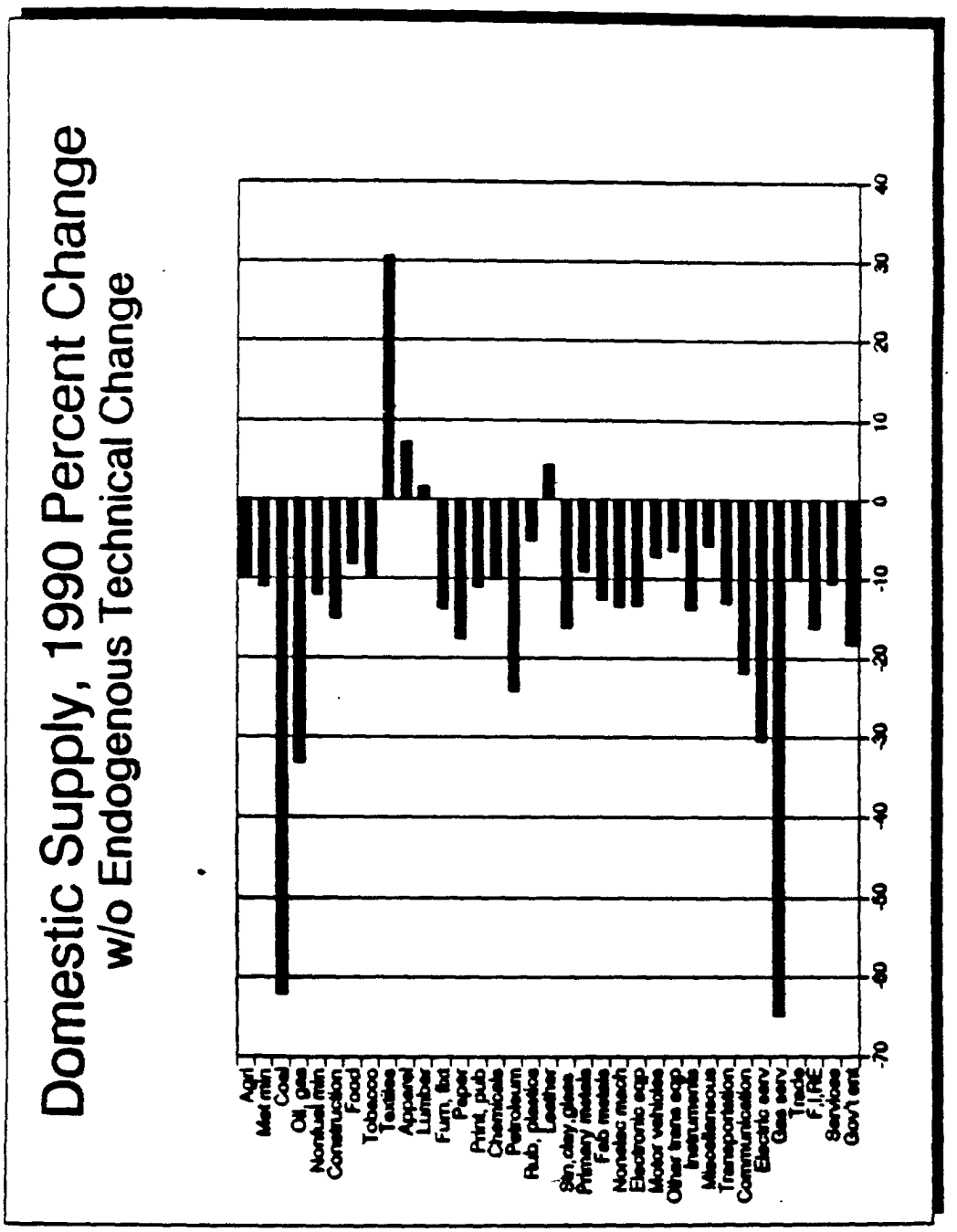
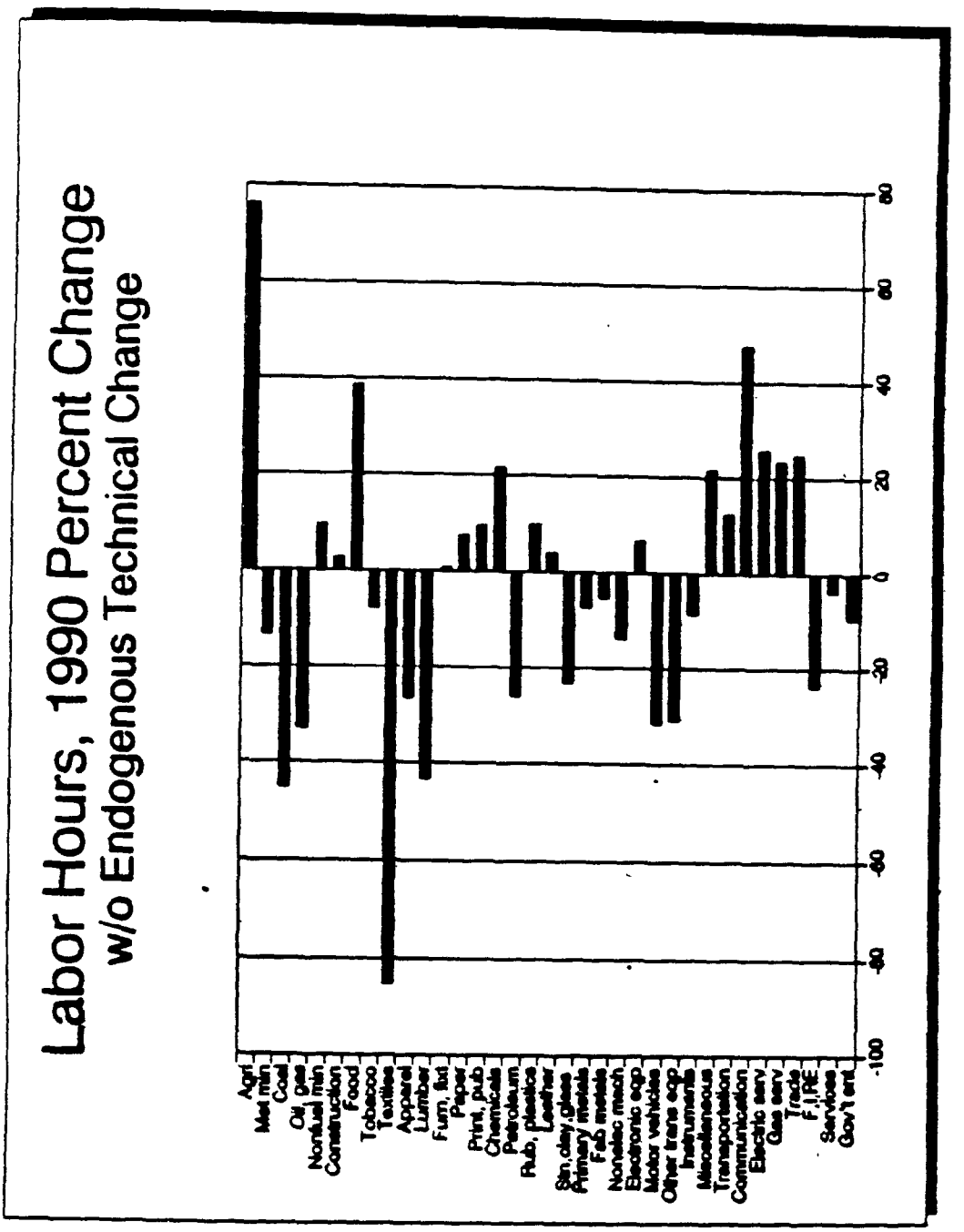

Domestic Supply, 1990 Percent Change
w/o Endogenous Technical Change
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
Agri
Met min
Coal
Oil, gas
Nonfuel min
Construction
Food
Tobacco
Textiles
Apparel
Lumber
Furn, fixt
Paper
Print, pub
Chemicals
Petroleum
Rub, plastics
Leather
Stn, clay, glass
Primary metals
Fab metals
Nonelec mach
Electronic eqp
Motor vehicles
Other trans eqp
Instruments
Miscellaneous
Transportation
Communication
Electric serv
Gas serv
Trade
F,I,RE
Services
Gov't ent

Figure 6.6


Labor Hours, 1990 Percent Change
w/o Endogenous Technical Change
80
60
40
20
0
-20
-40
-60
-80
-100
Agri
Met min
Coal
Oil, gas
Nonfuel min
Construction
Food
Tobacco
Textiles
Apparel
Lumber
Furn, fixt
Paper
Print, pub
Chemicals
Petroleum
Rub, plastics
Leather
Stn,clay,glass
Primary metals
Fab metals
Nonelec mach
Electronic eqp
Motor vehicles
Other trans eqp
Instruments
Miscellaneous
Transportation
Communication
Electric serv
Gas serv
Trade
F,I,RE
Services
Gov't ent

offsetting or in the case of leather reinforcing the output effects. Eighteen sectors show decreases in the use of labor services. As the technical biases are set to zero, output declines in fifteen of these. Twelve of the fifteen are labor-saving so that output changes leading to less labor demand are partially offset by the absence of labor-saving technical bias leading to more labor demand. The remaining three of the fifteen industries are labor-using so that the output effects on labor demand are reinforced by the absence of labor-using technical change. In textiles, apparel and lumber - the remaining three of the eighteen cases where labor services decline, output increases. These sectors are unique in that they are labor-,capital- and energy-using and materials saving. Thus, in absence of the estimated technical biases, they are labor-,capital- and energy-saving and materials-using relative to the base case. This and the reduced availability of capital input explain why labor demand decreases in spite of higher output.

With endogenous productivity growth, the elimination of the CAA compliance costs has a favorable and balanced impact on income, consumption, and the expansion of capital; all increase by generally the same proportional amounts (Table 5.2 and Figures 6.2 and 6.3). Without endogenous productivity growth, elimination of the CAA compliance costs has similar effects. The observed differences from eliminating the CAA costs with and without the technical biases depend on differences in the rates of capital accumulation, 1973-1990, and the synergy between it and the compounding influences of endogenous productivity growth. With the technical biases, elimination of the CAA costs increases the capital stock by an average of 0.9 percent and real income and consumption each by an average of 0.7 percent. Without the technical biases, these average increases arc reduced to 0.8 and 0.6 percent, respectively. More precisely, when the technical biases are removed, the gains from removing the CAA costs average 9 percent less for the capital stock, 13 percent less for real income, and 22 percent less for all consumption. In round figures then, endogenous productivity growth contributes from ten to twenty percent to the overall benefit of eliminating the CAA compliance costs.

Turning to the welfare consequences for these cases reinforces this general conclusion. As shown in Table 6.3, eliminating the technical biases imposes a welfare loss approximately eighty percent as large as the gains that accrue from removal of the CAA compliance costs. That productivity growth is welfare-improving and relatively progressive with respect to total expenditure certainly is not unexpected. Furthermore, since economic welfare depends on the time paths of prices, interest rates and total household expenditure and in view of the

Table 6.3
The Role Of Endogenous Technical Change

The Change in Social Welfare
with the Greatest Weight Given to Equality
Billions of 1990 Dollars

		With Technical Biases	Without Technical Biases	Differences
With CAA				
	Welfare	0	-398	-398
	Efficiency	0	-619	-619
	Equity	0	220	220
Without CAA				
	Welfare	493	-7	-500
	Efficiency	703	-75	-779
	Equity	-209	68	278
Difference				
	Welfare	493	391	-101
	Efficiency	703	543	-160
	Equity	-209	-152	57

Errors in differences or balances are due to rounding.

findings for real consumption, there also is no surprise that eliminating the technical biases having already removed the CAA compliance costs imposes little in the way of a welfare loss (relative to the base case). Households lose the benefits from improved productivity but gain from eliminating the CAA costs and these almost cancel one another.

The pattern of welfare effects measured here depends on the behavioral responses of households to the removal of endogenous productivity growth. In the JWS methodology, households possess perfect foresight with respect to prices and interest rates and act rationally within the limits of empirically observed behavior. As evidence of this, Figures 6.3 and 6.4 show time paths of the percentage differences in real consumption and investment relative to the base simulation (which includes endogenous technical change and the CAA compliance costs). In the presence of endogenous productivity growth, the elimination of the CAA compliance costs is illustrated with the shaded bars.

Because the elimination of endogenous productivity growth reduces real income by raising future prices, real household purchases, under perfect foresight and rational expectations, shift from the future to the present and, in fact, rise relative to the base case in the earlier years. As stated earlier, this reduces the savings flow from current income which further restricts investment (in addition to the effects of higher prices) and slows the rate of capital accumulation. In turn, this lowers future income and consumption. Changes in economic welfare over the long term (1973-2060) depend, in part, on the time path of expenditure changes. Omniscient household behavior in reaction to the absence of endogenous productivity growth leads to welfare gains arising from near-term increases in consumption through the late 1980's. However, these are more than offset by the long-term reductions in consumption that translate into welfare losses.

Eliminating the CAA compliance costs having already removed endogenous technical change is analogous to partially restoring lost productivity growth. Since the CAA costs rise over time (yielding their full proportional impact by 1990), the temporal pattern of unit cost reductions due to their removal is not unlike what occurs with endogenous productivity growth. The elimination of the CAA compliance costs boosts real income and consumption by lowering prices in all periods (again Figures 6.2 and 6.3). By raising real rates of return and lowering the rental price of capital services, there also are increases in current real saving and investment which increases the availability of capital over the 1973-1990 period (again Figure 6.4). Thus, the observed differences

from eliminating the CAA costs with and without endogenous technical change depend on slight differences in the rates of capital accumulation over the period of analysis, 1973-1990, and the dynamic interactions that follow from endogeneity.

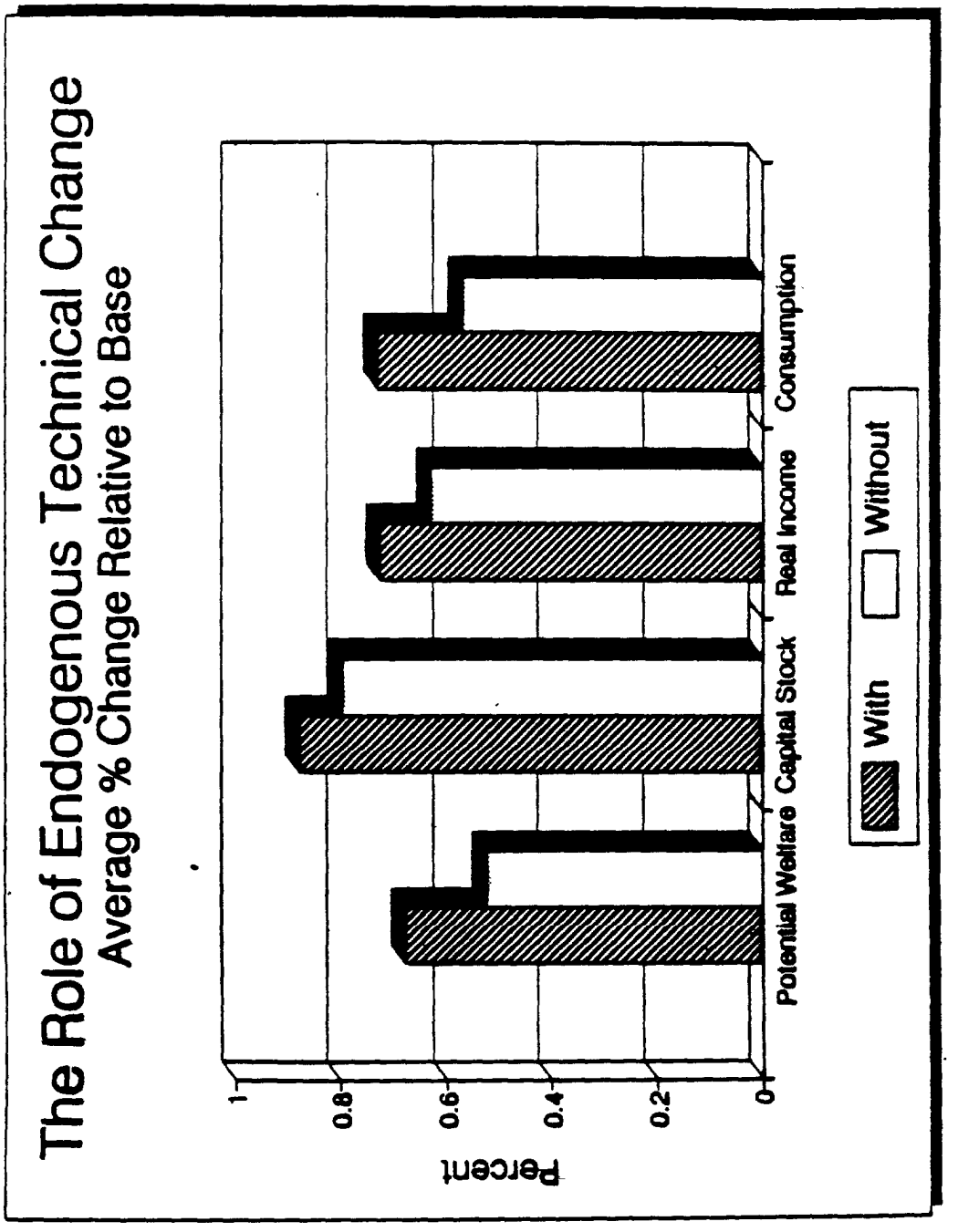
The principal conclusions from these analyses are as follows:

1) With households behaving rationally with perfect foresight and in the presence of empirically observed technical biases in simulated factor shares, the elimination of a substantial portion of the direct costs of CAA compliance secures a small long-term welfare benefit in the range of $(1990) 493 to 621 billion and this elimination is relatively progressive with respect to total expenditure. Conversely, compliance with the CAA provisions under these circumstances reduces aggregate social welfare and is regressive.

2) With households behaving rationally with perfect foresight and in the absence of empirically observed technical biases in simulated factor shares, the elimination of a substantial portion of the direct costs of CAA compliance leads to a smaller long-term welfare benefit in the range of $(1990) 391 to 494 billion and this elimination is relatively progressive with respect to total expenditure. Thus, compliance under these circumstances also reduces aggregate social welfare and is regressive.

3) Endogenous technical change is very important to the growth and structure of the economy within any given policy setting. However, it is substantially less important across policy environments. On the cost and price side, the complete absence of endogenous productivity growth (an extreme simulation with no compensating adjustments to the model or its parameters) erodes none of the benefits from CAA cost removal (Table 6.1). On the quantity side as illustrated in Figure 6.7, the absence of endogenous technical change reduces the gains by ten to twenty percent, depending on the measure chosen. This means between eighty and ninety percent of the benefits are solely the consequences of the policy changes. The contribution of endogenous productivity growth is small in comparison to the overall gains from CAA cost removal and, yet, serves to quantify an upper bound on the magnitude of the dynamic influences secured through this particular specification of observed behavior. More importantly, the absence of endogenous technical change alters neither the conclusion that the costs associated with CAA compliance are harmful to economic performance and welfare nor the causal chain of adjustment that lead to this conclusion.

Figure 6.7


The Role of Endogenous Technical Change
Average % Change Relative to Base
Percent
0
0.2
0.4
0.6
0.8
1
Potential Welfare
Capital Stock
Real Income
Consumption
With
Without

7. The Economy, Welfare and Foreign Savings

The most important impact of the CAA compliance costs is on the process of capital formation. Indeed, the ultimate size of the benefit from their elimination depends on the cumulative gains produced through accelerated capital growth. In these simulations, the effects on investment stem entirely from changes in household and producer behavior. The interest rate adjusts to align private domestic savings and investment and to equilibrate the commodity-based price of new capital goods with the discounted value of future capital rental prices.

Two assumptions are extremely important to the eventual outcome for investment and capital accumulation. These concern the government budget deficit and the current account trade surplus. Specifically, it is assumed that these are independent of any policy changes prompted by the CAA. Government expenditures adjust to achieve balance between endogenous government revenues and the exogenous budget deficit. In addition, the supply of foreign savings is assumed to be perfectly inelastic with respect to changes in U.S. interest rates. Operationally, the exchange rate is altered to restore the net inflows of foreign savings to their exogenous levels.

In the basic CAA analysis, it is assumed that the current account surplus is held constant in nominal U.S. currency. To achieve this, the dollar strengthens implying that the current account surplus would have been larger (or the net inflow of foreign saving would have been smaller) in the absence of this strengthening. *Ceteris paribus,* elimination of the CAA compliance costs stimulates export demand and the demand for petroleum and motor vehicle imports while it reduces the demand for imports of other goods and services. On balance, this increases, again *ceteris paribus,* the current account surplus or, equivalently, lowers the net inflow of foreign savings. For a given level of domestic savings, this reduces private investment. However, under the assumption that the net inflow of foreign savings remains unaffected by the removal of CAA costs, the dollar must strengthen. This is not a prediction of an economic impact but rather a condition that is necessary to achieve perfectly inelastic savings behavior (measured in current U.S. dollars) on the part of foreigners.

Because there is no knowledge concerning the willingness of foreigners to lend to the U.S. as CAA policies change, the choice of precisely how to value the

assumed unchanged levels of foreign savings is somewhat arbitrary. To this end, two alternatives are considered. In the first, the current account surplus is held fixed across cases in nominal foreign currency. In the second, the current account surplus is held fixed across cases in real U.S. dollars. In each instance, the exchange rate is required to adjust to restore the current account balance, appropriately denominated, to those levels existing with the CAA in place.

The effects of these alternatives are presented in Figures 7.1 through 7.5. As can be seen, they have an extremely small impact on the overall conclusions for his assessment. Essentially, the appreciation of the dollar required to restore the current account surplus denominated in foreign currency is less than that required for the surplus measured in U.S. dollars. The dollar appreciation is lesser still for the real (U.S.) current account surplus. Because the dollar appreciations are less (Figure 7.1), the current account surplus in current U.S. dollars is slightly higher in each of these alternatives implying lower net inflows of foreign savings. This has an extremely small but adverse impact on the investment available from domestic and foreign savings (Figure 7.2). As investment is reduced at the margin, the increases in capital availability and real income are slightly lower (Figure 7.3). The benefits to consumer spending from elimination of the CAA compliance costs gradually erode across these alternatives as the average change in the current account surplus (in U.S. dollars) gradually rises (Figure 7.4). Finally, motor vehicle and petroleum imports are affected by a combination of forces (Figure 7.5). As the dollar strengthens, the U.S. price of imports falls (given exogenous import prices in foreign currency) which encourages additional imports. Since the dollar strengthens less across each case, import increases are smaller. This exchange rate effect is reinforced by the combination of impact on domestic prices and demands. Smaller price reductions and smaller increases in incomes, production and spending mean less demand for imports. Again, the import increases diminish across cases. (Additional information on the economic adjustments to these alternative specifications are presented in Appendix D.)

The welfare effects for these alternatives are summarized in Table 7.1 (with details again provided in Appendix D). As can be seen, variations in the assumptions regarding foreign savings behavior have an *extremely* small impact on the overall conclusions for this assessment. The welfare benefits from elimination of the CAA compliance costs gradually erode across these alternatives as the average change in the current account surplus (in U.S. dollars) gradually rises. For all practical purposes, there is no quantitative or qualitative difference in the welfare effects estimated for these alternatives.

Figure 7.1

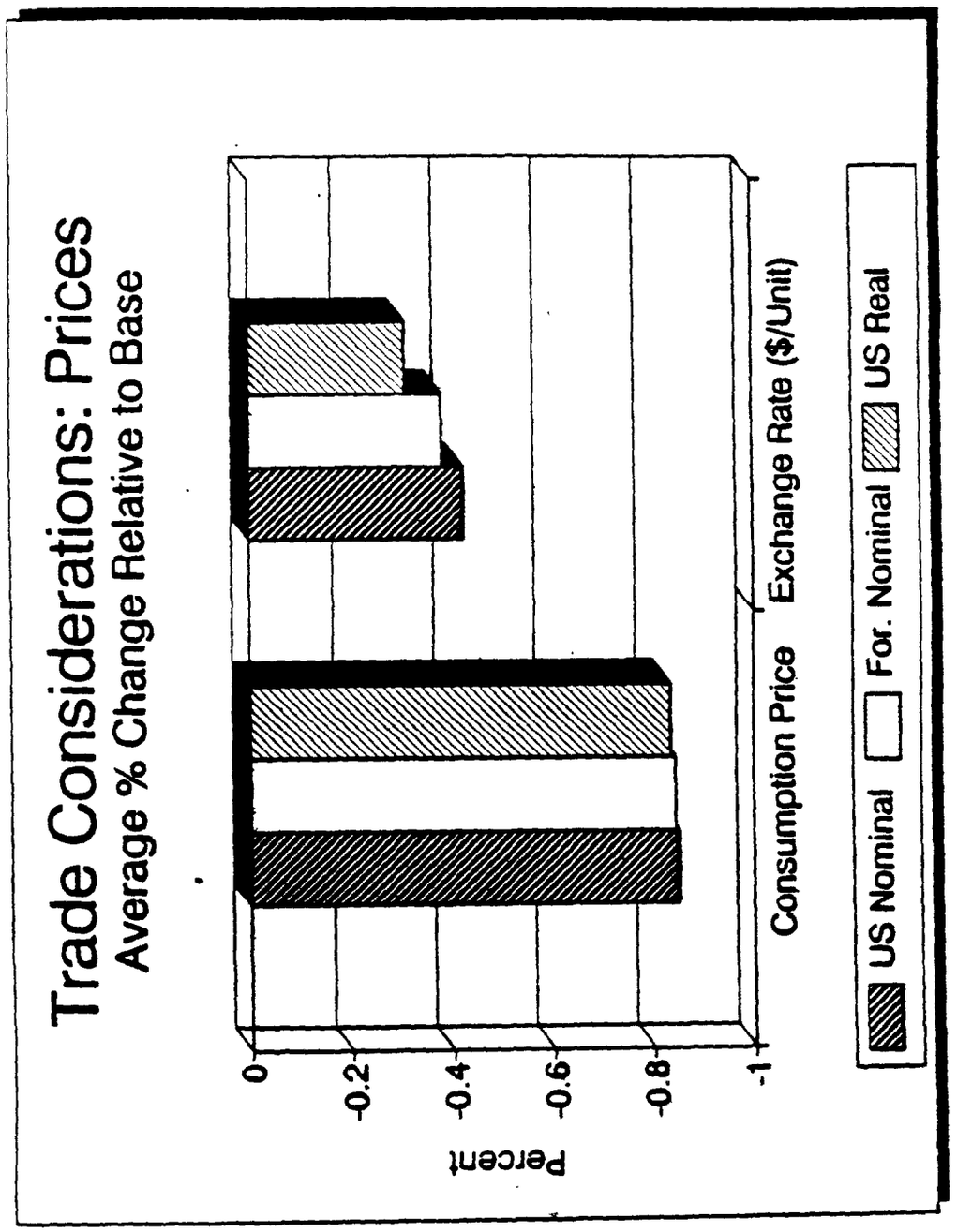

Trade Considerations: Prices
Average % Change Relative to Base
Percent
0
-0.2
-0.4
-0.6
-0.8
-1
Consumption Price
Exchange Rate ($/Unit)
US Nominal
For. Nominal
US Real

Figure 7.2

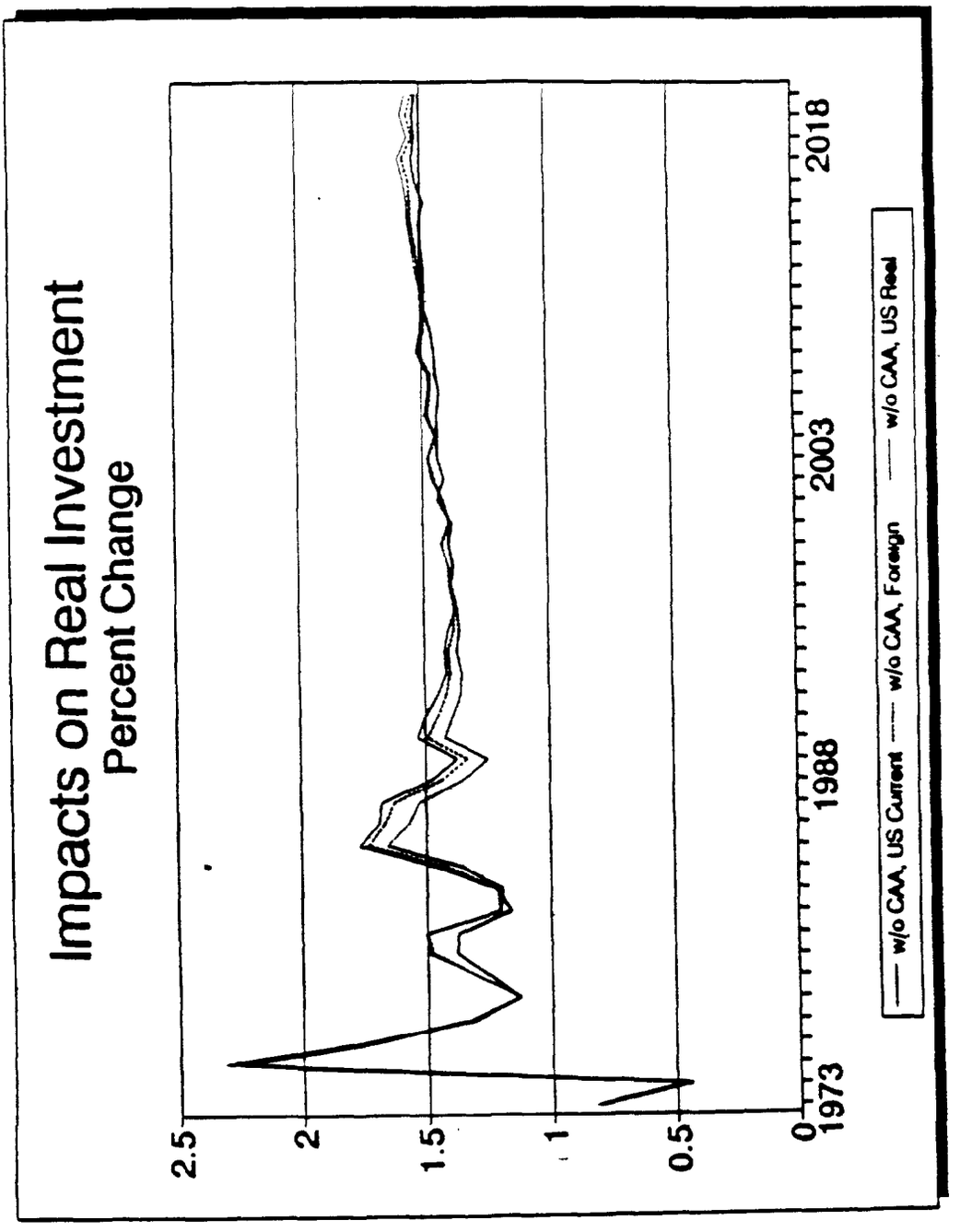

Impacts on Real Investment
Percent Change
2.5
2
1.5
1
0.5
0
1973
1988
2003
2018
w/o CAA, US Current
w/o CAA, Foreign
w/o CAA, US Real

Figure 7.3

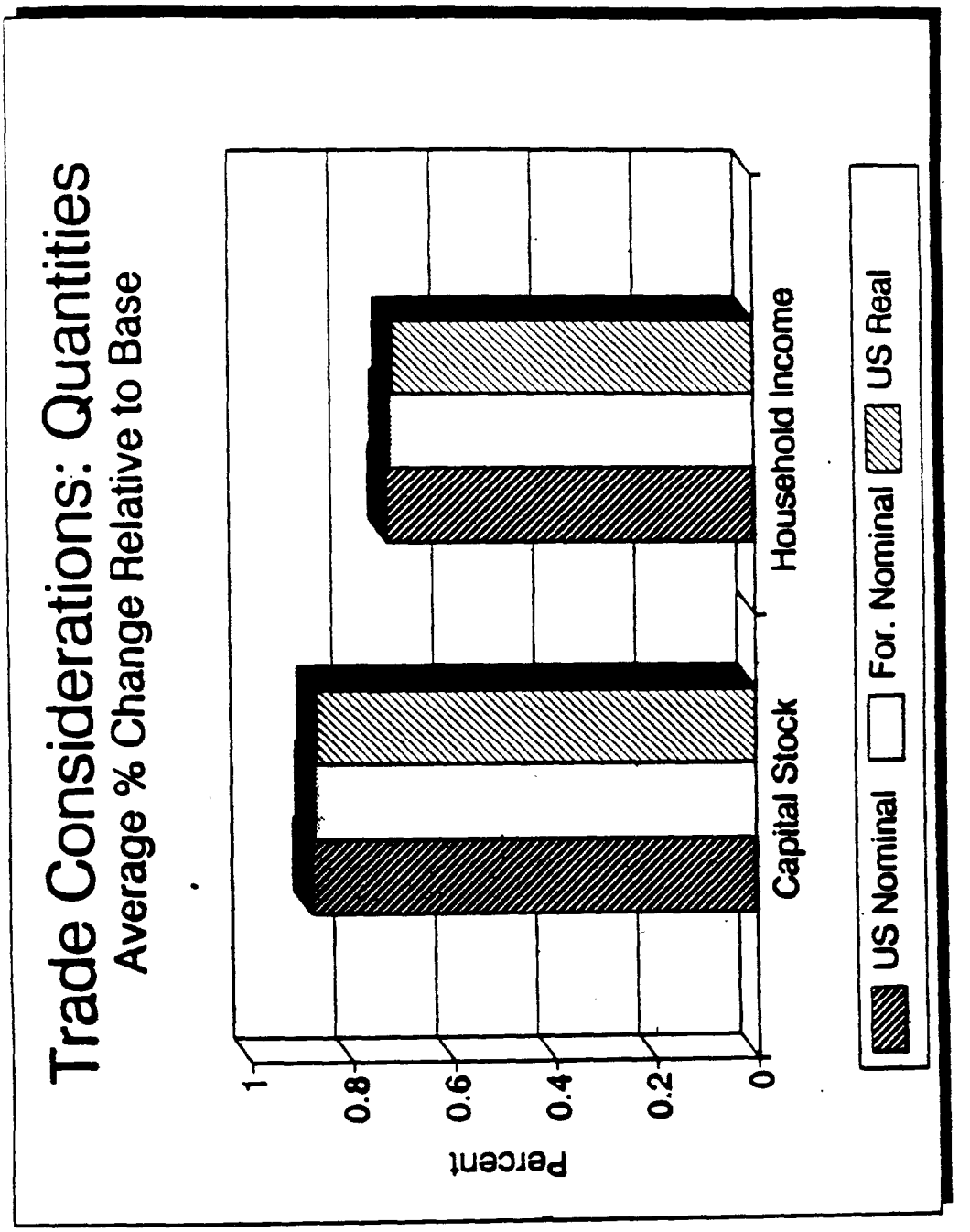

Trade Considerations: Quantities
Average % Change Relative to Base
Percent
1
0.8
0.6
0.4
0.2
0
Capital Stock
Household Income
US Nominal
For. Nominal
US Real

Figure 7.4

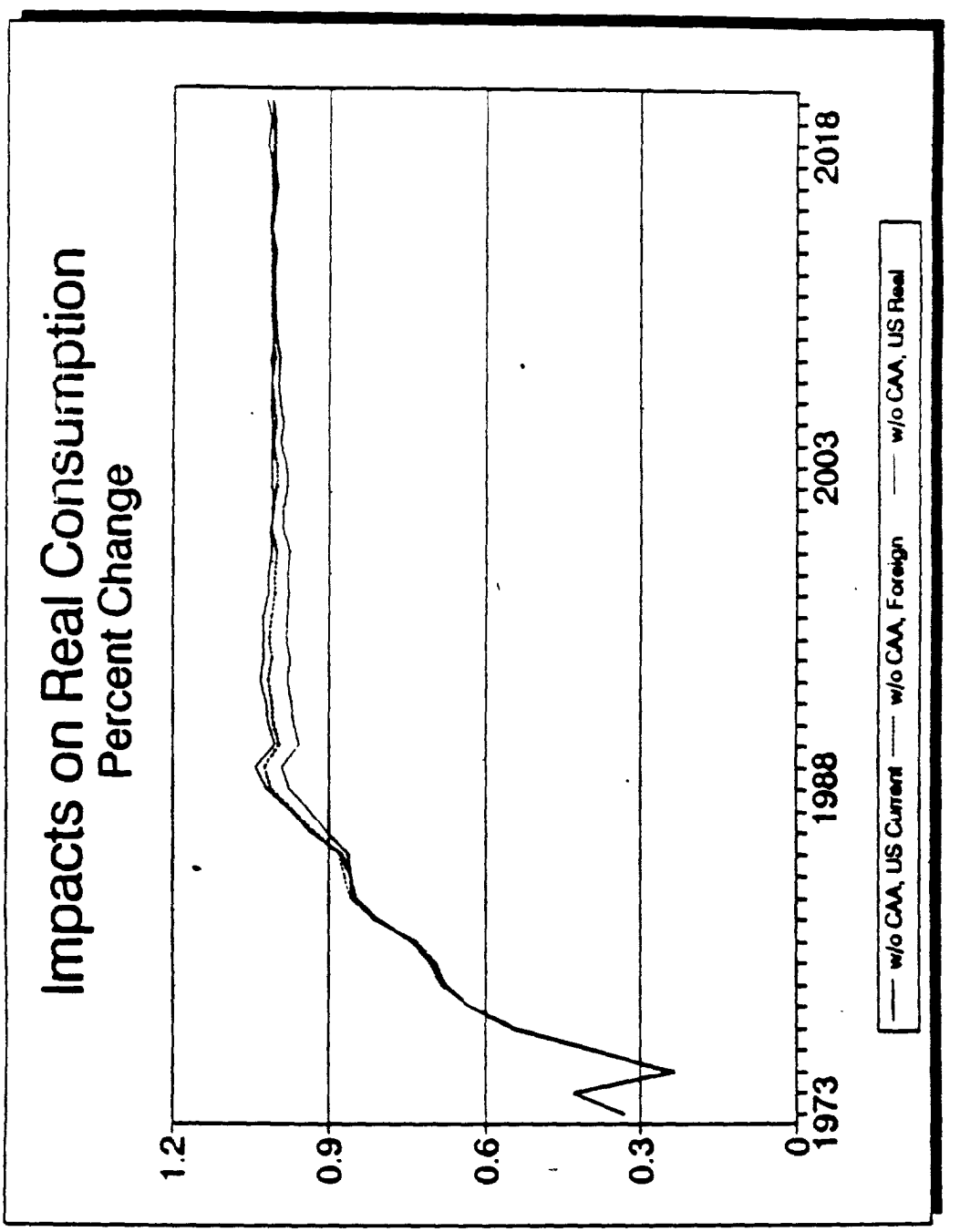

Impacts on Real Consumption
Percent Change
1.2
0.9
0.6
0.3
0
1973
1988
2003
2018
w/o CAA, US Current
w/o CAA, Foreign
w/o CAA, US Real

Figure 7.5

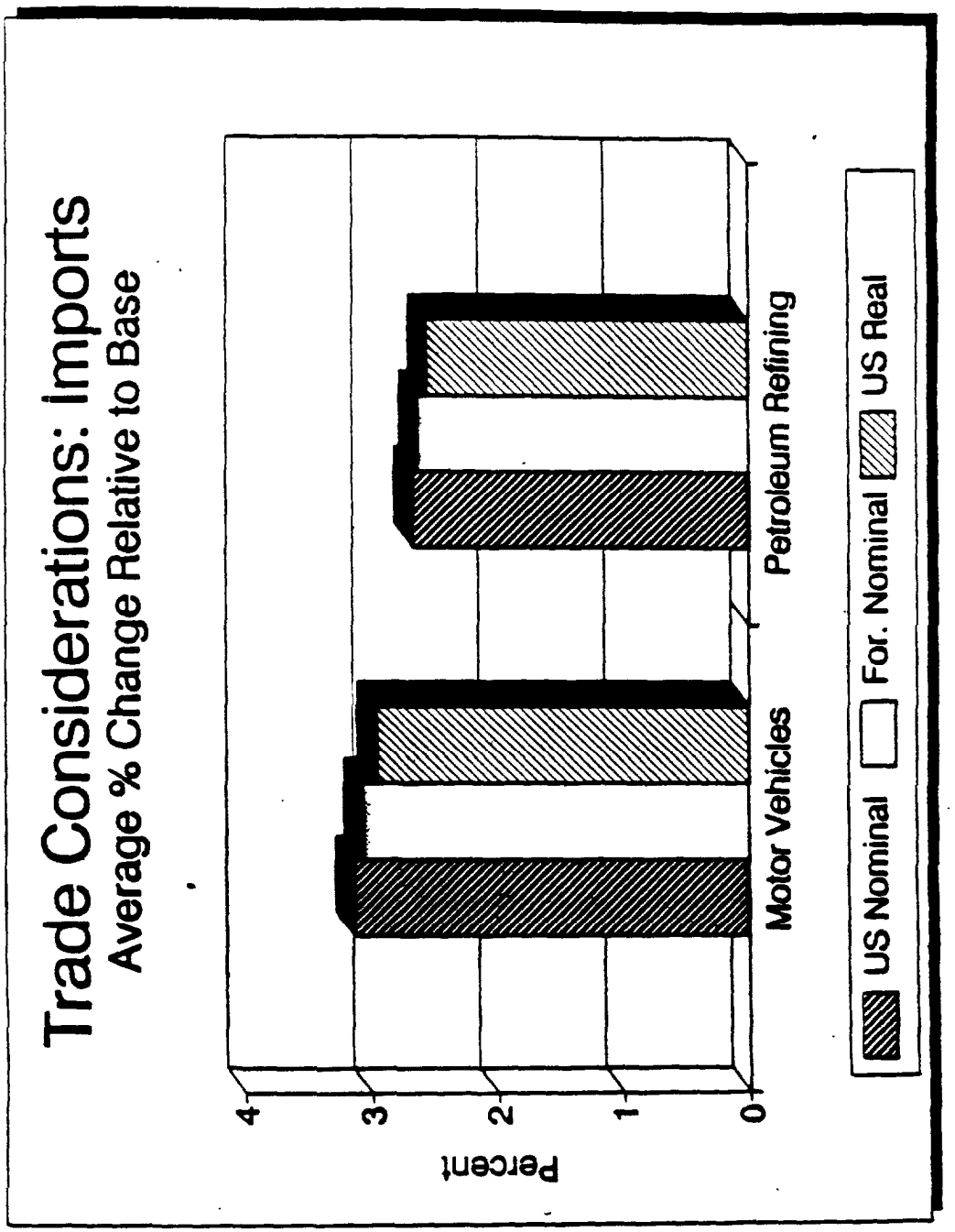

Trade Considerations: Imports
Average % Change Relative to Base
Percent
0
1
2
3
4
Motor Vehicles
Petroleum Refining
US Nominal
For. Nominal
US Real

Table 7.1
Compliance Costs And Social Welfare
Alternative Denominations For
The Current Account Surplus

The Change in Social Welfare
*Greatest Weight Given **to** Equality*
Billions of 1990 Dollars

Current Acct. Surplus Held Constant In:		Current U.S. Dollars	Foreign Currency	Difference
Without **CAA**				
	Welfare	493	490	-3
	Efficiency	703	697	-7
	Equity	-209	-207	3

		Current U.S. Dollars	Constant U.S. Dollars	Difference
Without CAA				
	Welfare	493	486	-7
	Efficiency	703	687	-16
	Equity	-209	-201	8

Errors in differences or balances are due to rounding.

Appendix A

Compliance Costs:
Sources, Methods and Database

A.1 Compliance Cost Sources

CAPITAL EXPENDITURES

U.S. Environmental Protection Agency. *Environmental Investments: The Cost of a Clean Environment.* November 1990

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business.* Selected Issues

Historical data, 1973-89. EPA estimates, 1990.

OPERATING & MAINTENANCE EXPENDITURES

U.S. Environmental Protection Agency. *Environmental Investments: The Cost of a Clean Environment.* November 1990

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business.* Selected Issues

U.S. Department of Commerce, Bureau of the Census. *Current Industrial Reports: Pollution Abatement Costs and Expenditures 19__* .

Historical data for non-farm business aggregates
- 1973-1984 Complete
- 1985-1986, Revised data allocated on the basis of historical 1985-1986 shares
- 1987-1989, Revised data allocated on the basis of historical 1986 shares
- 1990 EPA estimates allocated on the basis of 1986 shares

Historical data for sectors within manufacturing
- 1973-1986, 1988 Complete
- 1987 Survey not taken or published. Numbers determined on the basis of historical shares within total manufacturing
- 1989-90 totals allocated on the basis of 1988 shares

RECOVERED COSTS

U.S. Department of Commerce, Bureau of the Census. *Current Industrial Reports: Pollution Abatement Costs and Expenditures, 19__*.

Historical data for manufacturing
- 1979-1986, 1988 Complete
- 1987 Survey not taken or published. Numbers for 1973-78 and 1987 determined on the basis of historical shares of total recovered costs
- 1989-90 totals and allocation based on 1988 shares

MOBILE SOURCES

U.S. Environmental Protection Agency. *Environmental Investments: The Cost of a Clean Environment.* November 1990 and Revisions.

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business.* Selected Issues

U.S. Department of Labor, Bureau of Labor Statistics. *Producer Price Indexes.* Selected Supplements

Historical data, 1973-1989. EPA estimates, 1990.

OTHER SOURCES

U.S. Department of Commerce, Bureau of Economic Analysis. *The National Income and Product Accounts of the United States.* Selected Releases

U.S. Department of Labor, Bureau of Labor Statistics. *Time Series on Input-Output Industries.* Selected Releases

Historical data, BEA, 1973-90, and BLS, 1973-89.

A.2 Compliance Cost Estimation Methods

Operating & Maintenance Expenditures: Manufacturing

Missing values in the Census data at the two-digit level were estimated, generally by linear interpolation. Depreciation expenses were removed from the annual O&M expenditures using the 1979 value share (the only year available). The resulting O&M outlays were aggregated across sectors to yield an industry total by year. Value shares then were computed from the sectoral data and the industry totals. The result was a matrix of sectoral shares of total O&M outlays for manufacturing in each year, 1973-1988. Share values for 1988 were used for 1989 and 1990. These share values were applied to the BEA (EPA) O&M totals for all manufacturing to yield the compliance costs reported below.

Recovered Costs: Manufacturing

Missing values in the Census data at the two-digit level were determined in one of two ways. Where data were present, the average share of air recovered costs in total recovered costs was applied to total recovered costs. This provided data for those situations in which total recovered costs were available but air recovered costs were not. The remaining missing values were estimated, generally by linear interpolation. These results then were aggregated to yield air recovered costs for total manufacturing by year. In many instances, these are very close to BEA's figures for all air-related recovered costs, manufacturing and non-manufacturing alike.

Operating & Maintenance Expenditures: Non-manufacturing

BEA capital expenditures on air pollution control equipment for non-manufacturing aggregates were allocated to sub-aggregates on the basis of BLS industry output shares. The capital expenditures were accumulated over time within each non-manufacturing sub-aggregate and aggregate capital by year was determined. Capital value shares by year for the sub-aggregates then were computed and applied to the BEA (EPA) O&M expenditures for the non-manufacturing aggregates to yield the compliance costs below.

The compliance costs used in this analysis are reported fully in the pages that follow.

	O&M Expenditures, $Mn				
Ind.	Metal mining	Coal mining	Crude & natural gas	Non-metallic mining	Construction
Year					
1973	5.83	8.14	27.93	6.51	42.11
1974	6.87	11.91	36.84	7.41	43.06
1975	7.69	15.70	45.22	8.67	50.85
1976	11.27	25.78	71.05	12.85	52.18
1977	15.26	37.39	105.04	18.06	59.28
1978	18.79	46.67	134.05	22.72	65.75
1979	22.99	57.10	168.50	27.46	68.40
1980	26.68	66.52	210.34	31.75	81.30
1981	29.37	73.88	250.14	35.03	92.52
1982	26.35	69.44	248.91	32.15	80.33
1983	29.66	79.73	295.28	36.78	91.21
1984	34.03	93.33	352.50	42.90	104.11
1985	36.37	101.87	390.32	46.76	110.76
1986	36.88	106.02	402.79	48.59	113.96
1987	37.60	110.42	417.47	50.69	115.95
1988	35.82	106.95	400.80	49.40	114.10
1989	37.09	111.96	417.17	52.19	121.20
1990	40.53	123.95	459.21	58.24	135.43

	O&M Expenditures, $Mn				
Ind.	Food & products	Tobacco	Textile products	Lumber & products	Furniture & fixtures
Year					
1973	31.82	1.80	4.19	9.65	2.89
1974	37.31	2.67	5.87	11.87	3.53
1975	40.90	3.07	5.90	13.89	3.77
1976	43.96	3.50	5.72	16.13	4.44
1977	44.58	3.35	6.81	12.67	5.65
1978	53.30	3.92	11.91	16.93	4.96
1979	66.20	4.33	11.28	23.27	6.15
1980	63.54	4.51	10.55	24.54	6.74
1981	61.31	5.60	12.08	26.92	6.73
1982	59.22	6.54	9.28	16.14	5.51
1983	74.22	6.90	13.43	19.12	8.17
1984	78.01	9.57	16.22	25.25	9.73
1985	82.61	10.38	19.61	25.85	13.35
1986	100.22	9.27	18.51	39.06	16.89
1987	115.99	9.08	19.69	47.40	18.48
1988	123.72	8.27	19.52	52.42	18.82
1989	130.97	8.76	20.67	55.49	19.92
1990	146.60	9.80	23.13	62.11	22.29